

# PERTH'S ENGINEERING HERITAGE – WALKING TOUR GUIDE

## 1. Engineers Australia

Murray street is the current home of the Western Australian Division of Engineers Australia, a representative body for Professional Engineers in Australia. Purchase of the land in 1958 for new offices spaces and a hall was to service approximately five hundred professional engineers and two hundred student members in Western Australia at the time. Today, the Murray Street office services approximately 13,860 Western Australian members.

The constructions and redevelopment over the years of the auditorium, assembly room, board room and committee rooms within the Perth office has allowed Engineers Australia to facilitate technical presentations, Continuous Professional Development (CPD) sessions, professional interviews, host events and workshops for the engineering community and its members in Western Australia.

## 2. No. 3 Electricity Substation

This is one of four original electricity substations that formed the 'Ring Main' of Perth's early electricity supply system.

For more information, see the entry for Site 23: No.2 Electricity Substation on Murray Street.

## 3. Perth's first Observatory

The original Perth Observatory was completed in 1897, principally to record meteorological and astronomical observations, issue weather forecasts and provide time services.

Within the first decade, the first Government Astronomer, W. E. Cooke, developed an electrical time service that linked the Perth Observatory State-wide. It provided time signals to Fremantle for shipping, the State railways, the post office telegraph system, and controlled public clocks in Fremantle and Perth. In 1901-02, a time cannon was set up to fire a daily 1pm time signal.

Meteorological observations were collected from recording stations located State-wide and collated for annual publication. Weather forecasts were published in Perth's press and also displayed in prominent places around the city.

In 1900, Perth Observatory participated in the International Star Cataloguing and Mapping Program, making a notable contribution to the program. Cooke improved the methods in use by the program which gained international recognition.

In the early years, the Observatory co-ordinated the surveys and the mapping of the State, including survey work that set out sections of the Western Australia borders with South Australia and the Northern Territory. The Observatory recorded seismological readings, providing important records for geophysical research. Furthermore, it provided tide tables and sunrise / sunset information for WA ports, the press and the general public.

The Observatory became a place of public interest, with people coming to enjoy the views over the city, or to use the telescope to view stars and planets. In 1912, an additional telescope was purchased to meet public demand. Public lectures in astronomy were held in the evenings.

The Office of the Commonwealth Weather Bureau was located at Perth Observatory from 1930 to 1967, coming under RAAF control during WWII. Monitoring of earthquakes continued until 1959.

In 1955, planning for Metropolitan Perth proposed the relocation of State government offices to the Observatory site, close to Parliament House. Design of new buildings commenced in the early 1960s. The observatory building itself was demolished to make way for Dumas House and the Observatory moved to Bickley. The building which remains is the original house and office constructed for the WA Government Astronomer.

### *Walking Directions:*

City West walk: Carefully cross Malcolm Street and head along Fraser Ave into King's Park. continue past the various memorials to site 5: City View, at the Kaarta Gar-up lookout.

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### 4. Dumas House

Dumas House is an imposing fourteen storey structure described by David Brand (then Premier) at its opening as 'a big building, and I think, a handsome one'. It was constructed for the State Government of Western Australia during a period of increased prosperity. It was the first of five planned buildings to be located on the site to centralise Government (the Parliament House project), but due to increased traffic and a perception of 'dominance by the bureaucracy' the other four were never built.

Originally named 'Government House' the building was renamed in 1978 in honour of Russell Dumas a former Director of Works and Buildings for the Public Works Department that was housed here until its dissolution on 30 June 1985. The building is still home to many departments of the State Government of Western Australia.

An architectural competition was held for the design of the proposed new building, with sixty-seven entries received. First prize was won by the Public Works Department Architects G. Finn, E. Van Mens & P. Maidment. Their design required that the site be cleared of all existing buildings, the site filled and levelled. The master plan for the proposed five buildings allowed for progressive development meaning that Hale School and the Old Observatory (now home to the National Trust) were reprieved. However, the smaller buildings associated with the observatory (the Transit Circle Building and the Dome - used for taking telescopic photographs of the night sky) were demolished to make way for the car park.

Designed in the Post-War International style, the building has a concrete encased steel frame with 2 basement levels, fourteen above ground levels and an open piazza at ground floor level. The projecting balconies are an adaptation of the architectural style to suit the Australian climate, providing protection during the summer. From 2015-2018 the building underwent a full façade refurbishment with all new precast concrete cladding, terracotta blockwork, extensive concrete repairs to the underlying structure and replacement waterproof membranes to the podium and balconies. The building, which is listed on the State Heritage Register) is now much as it would have appeared at the opening in 1966, with the repairs strictly following the guidelines of the Burra Charter.

[see also site 20: Sir Russell Dumas pavement marker]

*Walking Directions:*

City West walk: From here you can see site 3: Perth's First Observatory.

### 5. City View

The Derbarl Yerrigan (the Indigenous name for the Swan River), initially vital in communication within the new colony, now plays a significant role in Perth's identity. Perth was founded in 1829 and over the years the land between the CBD and the river have been reclaimed and improved with the foreshore continuously evolving to reflect the culture and needs of the time. As a result, the Perth city skyline and foreshore have been dramatically shaped by the work of engineers.

The Perth site was once a sandy and marshy river terrace unable to support building foundations but the first reclamation project commenced in 1873 and was completed by 1880, resulting the Esplanade Reserve, which was again re-profiled in 2011 to develop Elizabeth Quay. Further reclamation projects included the establishment of the Supreme Court Gardens, Langley Park, Point Fraser, the island in which the Causeway Bridges crosses, Mounts Bay, Narrows Bridge, Barrack Square and the Mitchell Freeway Interchange into what Perth is today.

*Walking Directions:*

City West walk: Facing away from the city, walk up the hill to Wadjuk Way and site 6: Perth's first water supply scheme.

### 6. Perth's first water supply scheme

Early colonists usually dug wells in Perth and Fremantle for their everyday water needs. However, when the population started to rapidly increase in the late 1890s due to the first gold rush, summer water shortages were common. Pollution in the wells resulted in the spread of diseases such as typhoid, and the need for a safe public water supply became urgent.

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In May 1887, Perth civil engineers Henry John Saunders and James Barratt prepared a proposal to construct a dam and pipeline from Munday Brook, located in the hills to the east of Perth.

Saunders and Barratt's proposed water supply scheme included the Victoria Reservoir, a new 140 million gallon storage dam located in the Darling Range east of Perth, as well as 16½ miles of 12 inch trunk main, a 1,260,000 gallon service reservoir at Mt Eliza and city reticulation.

Site clearing commenced in October 1889 and the site was ready by the time the cement and pipes started to arrive four months later from England. When Victoria Reservoir was opened on 1 October 1891, the rapidly growing State's population was less than 50,000 and Perth's first public water supply scheme was a major undertaking.

### *Walking Directions:*

City West walk: Walk around the Kings Park gallery then head back east to site 7: Wartime Engineers, at the State War Memorial.

## 7. Wartime Engineers

Members of the fledgling Western Australian Institution of Engineers made a significant contribution during World War 1. Of the 146 members, one in seven enlisted, to apply their skills in tunnelling, surveying and providing infrastructure, as well as combat. Five members were lost and many were wounded. Most enlisted early in the conflict and typically served in Gallipoli and France, living within a few hundred meters of thousands of Turkish or German opposition.

Institution members acquitted themselves well earning four military crosses and one distinguished service order. Ten members were commissioned as officers, with two members, Geoffrey Drake-Brockman and Sidney Ernest Evans reaching the rank of Colonel in the Second World War.

The recipient of the Distinguished Service Order, Major Fredrick Washington Lawson, was the Chief Engineer of the Metropolitan Water Supply and Sewerage Department. On his

return he went on to become the founding Vice President of the Institution of Engineers, Australia. His DSO citation reads as follows:

Major Lawson has been in charge of the Corps water supplies during the period that 1st ANZAC Corps have held the present front, on our taking over this area no water supply existed east of Zillebeke, owing to the impossibility of keeping the water main in operations due to the heavy artillery fire. Major Lawson however did the impossible and by 20th September (1st Battle of the Menin Rd) he had carried his water mains to Bellewaerde Lake and supplied the Advance troops. Major Lawson personally superintended the repairs during the 1st, 2nd and 3rd battles and has continually advanced his mains. He has set an example of devotion to duty and fearlessness which has kept his detachments at work under the severest conditions.

### *Walking Directions:*

City West walk: Follow the Kokoda Track Memorial walk around to the west and down the hill to Mounts Bay Rd and site 8: Perth's first steam mill.

## 8. Site of Perth's first steam mill

Ahead near the old brewery was the site of the first steam mill in the colony, built by John Schoales and George Nash. A letter to the editor of the Western Mail on 22 Sep 1900 described the difficulties experienced by many early projects in the colony:

"The steam mill was commissioned July 1839 after the boiler was imported in January. Its owners hopes ran very high, as they were under the impression that they could do all the grinding for the whole colony. But, unfortunately, the project turned out a terrible failure, owing to the difficulty in getting wheat to the mill, as there were no fine roads around the Mount to the mill, and most of the wheat had to be conveyed in boats.

"Another great drawback was the want of a competent person to set the engines in proper working order. The late Mr. James Lockyer was the millwright, and appeared to understand his part of the work, but the man who had the management of the engines did not seem to understand the machinery.

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"The consequence was a break down almost every week, causing delay and expense, and in a short time the owners were compelled to close the mill doors and turn the mill into a depot. Poor Mr. Schoales broke down through misfortune and disappointment, and died in Perth on April 10, 1847, aged 37, a poor but honourable gentleman."

*Walking Directions:*

City West walk: Carefully cross Mounts Bay Rd and follow the cycle path east along the foreshore. After passing under the bridge, turn left up the hill to the bridge abutment footpath and site 9: Mitchell Freeway.

### 9. Mitchell Freeway

Stage 1 of the Mitchell Freeway was a highly significant undertaking in road infrastructure in Australia. Completed in 1973, the Stage 1 freeway comprised three distinct sections, each with their own engineering challenges and innovations. At the northern end, the Hamilton Interchange consisted of cast-in-situ box girder post tensioned concrete bridges over Wellington, Roe, Aberdeen and James Streets and the Perth to Fremantle railway. These bridges were unique in Western Australia in that it was the first time large multi wired prestressing cables were used, requiring a 500 tonne capacity prestressing jack to tension the cables.

The central section used three reinforced concrete cast in situ box girder bridges on reinforced concrete piers. The deep cutting through a built-up area required 230,000 cubic metres of excavation and 1.8 kilometres of reinforced concrete retaining walls up to 6.6 metres tall. For the first time in Western Australia large sheets of waterproof plywood were imported from NSW to be used in the retaining wall formwork, thus minimising off form joint marking. For the first time in WA freeway standard road pavements were constructed.

At the southern end, the Narrows Interchange was the largest section of the project. The interchange consists of 26,550 square metres of prestressed concrete bridge deck and 29.4km of freeway-standard road pavements. Four years before bridge works commenced, the Main Roads Department began stabilising the mud layers of the reclaimed area around Mounts Bay Road by installing 43,000 vertical sand drains, about

800 km in total length. Approximately three million cubic metres of sand was trucked to the site to consolidate the mud and provide material for embankments. The scale of this stabilisation process was unique in Australian, and probably the world, civil engineering construction at that time.

In anticipation of further long term settlement the bridge foundations consisted of hollow jointed concrete caissons with the bridge piers built within them. The annular space allowed for possible differential horizontal and vertical ground movements. The combined length of the thirteen caissons sunk to a stable rock layer is approximately 450 metres. The caissons average mass is 2,000 tonnes and average length is 34.5 metres; the diameters varying from 7.4 to 10.8 metres. In total 41,000 cubic metres of concrete and 1,222 tonnes of high tensile steel were used in the project.

Among the buildings to be demolished in 1965 to make way for the freeway was the Barracks, a Perth landmark and link with Western Australia's convict beginnings. There was a vehement public outcry over the demolition of the buildings and as a consequence, part of the building complex, the Barracks Arch, on the edge of the freeway cutting, was retained. The Arch stands as a symbol of the beginning of an increased awareness of preserving the built heritage in Western Australia.

*Walking Directions:*

City West walk: Turn around to look south at site 10: Narrows Bridge.

### 10. Narrows Bridge

The original Narrows Bridge was constructed between 1957 and 1959. At the time it was the largest precast, prestressed concrete continuous beam bridge in the world. It incorporated a number of innovative technical features and met stringent engineering design and construction requirements of the State Government for an aesthetic, slim-line bridge in this prominent location. Linking the Mitchell and Kwinana Freeways, it was a critical part of Metropolitan planning which helped change the direction of Perth's development from an east-west to a north-south axis.

The bridge was designed by G Maunsell & Partners, and built by Christiani & Nielsen and J O Clough & Son for the Main Roads Department of WA. Its significance has seen it

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recognised as a National Engineering Landmark by Engineers Australia and given an entry on the State's Register of Heritage Places by the Heritage Council of WA.

By the 1990s traffic volumes on the bridge had greatly exceeded those envisaged at the time of planning. The bridge was considered one of the busiest stretches of freeway in the

country. A second road traffic bridge was built to the west of the original bridge, opening in 2001.

Further changes came with the decision to build the Perth to Mandurah railway. A new bridge to carry southbound trains was constructed in the 6-metre gap between the two road bridges. The western road bridge was strengthened, traffic lanes realigned and track laid to allow carriage of the northbound trains. The railway was opened in 2007.

From early thoughts of a river crossing here since the 1840s, the Narrows Bridge now fills an elegant and vital place in the infrastructure of the Perth region.

### *Walking Directions:*

City West walk: Continue east through the park, parallel to Riverside Dr to site 30: Elizabeth Quay Pedestrian Bridge

Optional detour: Cross the Narrows Bridge to visit site 11: The Old Mill (South Perth)

## 11. The Old Mill

In 1829 a young engineer, William Shenton, arrived in the Swan River Colony, bringing with him machinery for a sawmill. He soon realised there was a need for a flour mill to allow more efficient grinding of the wheat imported for the growing population. He constructed a horse-powered flour mill from timber at Fremantle.

Wheat began to be grown locally and in 1833 he designed a wooden windmill for a more convenient site on the South Perth peninsula. The mill was built by Paul and James Lockyer and incorporated equipment from the original Fremantle mill. To provide a stronger and more secure structure a new mill was built at the same site in 1835. This was constructed from limestone blocks, with the heavy cog-wheels being made from local tuart timber.

The foundation stone was laid at a ceremony conducted with Governor James Stirling. Lockyer and Son were again the builders. A cottage was built on the site in 1837.

The mill produced a peak of 1500lb (680kg) of flour per day and operated until 1859. Since then its various uses have included a hotel, residence, wine saloon and poultry farm. In 1973 it was classified by the National Trust for its cultural heritage significance.

The mill and cottage are now recognised as the oldest surviving links with the earliest days of settlement of the Colony. The buildings are reputed to be Australia's second oldest flour mill and Perth's oldest residence. They were most recently renovated in 2019 by the City of South Perth. They are open to the public from Tuesday to Friday 10am-4pm and on Saturday and Sunday 1-4pm, except on public holidays.

### *Walking Directions:*

Return to City West walk: Return across the Narrows Bridge, then continue east through the park, parallel to Riverside Dr to site 30: Elizabeth Quay Pedestrian Bridge

## 12. Barracks Arch

The Barracks Arch is all that remains of the former Pensioner Barracks. The Barracks was completed in 1866 and housed the Enrolled Pensioner Guard Force. This force was made up of Army veterans who joined up for six months full time service as guards on the convict ships, in return for land grants. At the end of their six months, they remained on call and had to parade a minimum of 12 days a year.

As well as dormitories, the barracks had 21 married quarters. Each family apartment had two rooms, each about 13 by 11 feet with at least one fireplace. Also on site was a separate cookhouse, firing range and gun-room, wash-house, stores and stables, and a fives (squash) court.

The Barracks were gradually converted to offices for the Public Works Department between 1900 and 1904, becoming its headquarters in 1904. Notable occupants included C. Y. O'Connor, whose office was immediately above the arch. The fives court housed the drawing office, and eventually connected to a mid-1920s addition for the Metropolitan

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Water Supply, Sewerage and Drainage department. The Public Works Department and Metropolitan Water Board moved to Dumas House in March 1966.

The Government intended to demolish the Barracks to facilitate the building of the Mitchell Freeway after the departments moved to their new location. The Royal Western Australian Historical Society formed a Barracks Defence Council who worked to keep the arch and five bays of windows either side, and at worst, keep only the gateway and towers. Meanwhile, demolition proceeded, with the third and fourth bays of windows demolished and rubble cleared.

A number of opinion polls were conducted to gauge the public's preferences, with the Premier Sir David Brand interpreting the results as indecisive. He declared Parliament would decide on the arch's fate on a non-party basis. The motion to demolish the arch was defeated on 19 October 1966, by 26 votes to 18.

The Barracks Arch blocks the otherwise unobstructed view from Parliament House down the length of St Georges Terrace and it was intended that demolition of the arch would provide unobstructed views, which was a prime argument advanced in favour of the demolition. This has now conversely been the argument for its retention – to always remind the Parliament that it exists to serve the wishes of the people not the other way round.

### *Walking Directions:*

City West walk: Continue up Malcolm Street to site 4: Dumas House.

### **13. C Y O'Connor pavement marker (1902)**

Charles Yelverton O'Connor, an Irish engineer, came to Western Australia in 1891 at John Forrest's invitation, from a civil engineering career in New Zealand. His commission was to build "railways, harbours, everything".

His first task was the construction of a safe harbour at Fremantle for the mail steamers that still only called at Albany. Because of the rock bar blocking the mouth of the Swan River, previous plans had been based on extensions to the outer harbour. O'Connor, by contrast, arrived at a characteristically independent and imaginative solution and

recommended the blasting of the bare rock and deepening of the estuary to create a safe inner harbour that would serve Fremantle for the foreseeable future. His harbour was opened in 1897 and the first P & O mail steamer berthed in 1900.

In the meantime, to 1896, O'Connor had also been acting general manager of the government railways. With his improvement and new lines, they made a profit for the first time. The problems of water shortage beyond the coast had been obvious during his administration of the railways but became acute with the development of the Eastern Goldfields. His engineers in the Goldfields Water Supply used all manner of means to provide water, but with limited success. O'Connor, again, looked for an innovative permanent solution - a Darling Range Dam with 525 km of pipeline to the Goldfields, supplying farmland on the way. Forrest supported the scheme and work began in 1898.

By the end of 1902 Mundaring Weir was completed, and pipeline and pumping stations installed. Overcome by bitter criticism of the project, O'Connor committed suicide and did not see the water flow into the Goldfields reservoirs or the farm development that followed the pipeline.

### *Walking Directions:*

City West walk: From here you can see site 12: Barracks Arch

### **14. Norman Brearley pavement marker (1921)**

Although Norman Brearley is not formally recognised as an engineer, his early development of the aviation industry revolutionised transport over Western Australia's vast distances.

By 1917 the railway had finally crossed the continent and a couple of intrepid motorists had even driven to Sydney, but it was a long, slow journey. Ships were still the only way of reaching the North, then horse or camel inland.

Brearley, born in Victoria, joined the Royal Flying Corps in WWI to become a pilot after less than two hours' instruction. He shot down several enemy aircraft Western Front before being seriously wounded, with both lungs punctured by bullets. On recovering, he became an advanced flying instructor and married a West Australian.

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When Brearley returned to WA after the war, he brought with him two military surplus Avro 504J bi-planes, purchased with his deferred services pay. With these he dazzled WA crowds with his stunt flying. “No exhibition could have revealed a more perfect control, a more easy confidence, or a more masterly handling of an aeroplane,” wrote The West Australian in August 1919 - even though on that occasion he brought down a fence and nearly got entangled in electricity cables, landing in the W.A.C.A. grounds.

In 1921 Brearley won the contract to operate a weekly passenger and mail air service between Geraldton and Derby in the Kimberleys, and was issued with the first pilot's licence under the Air Navigation Act of 1920. He selected and trained the pilots, including Charles Kingsford-Smith, who later became world famous for his long-distance record flights. By 1929 the company had also opened an air service between Perth and Adelaide using Hercules bi-planes carrying 14 passengers. But Brearley was the man who “personally introduced the science of flying ... to the people of this state”.

### *Walking Directions:*

City West walk: Continue west along St Georges Terrace and up the hill to site 13: C. Y. O'Connor pavement marker (1902)

### **15. James Thompson pavement marker (1925)**

James or Jas Thompson as he was known, was an Irishman with colonial engineering experience. Recruited by O'Connor he came to WA in 1891 to work as a field engineer in charge of railway construction with O'Connor as his Chief. He held that position to 1912, and from 1904 to 1925 was the Public Works Department's Engineer in Chief with the oversight of all public works projects during Western Australia's 'great railway age'.

The map of railway development was the map of economic development; the first Government line ran from Geraldton to Northampton from 1879 to service the lead and copper mines, then came the Fremantle to Guildford line and on into the Avon Valley agricultural districts, and the land-grant railways in the 1880s, then the Goldfields' lines of the 1890s. The great railway boom over which Thompson presided criss-crossed the Wheatbelt with light lines.

In the second half of the twentieth century railway construction followed the mineral boom, with the privately constructed iron-ore lines of the NorthWest and the standard gauge line from Kalgoorlie to the Kwinana industrial area.

Many of the lines built in Thompson's time for the Wheatbelt are now closed. They were part of the Government's overall policy of assistance to the new eastern-land farmers; built quickly and cheaply (sleepers were sometimes cut from the trees nearby) and often running at a loss. Lines extended in a network of loops and sidings which meant that few farmers were more than 25kms from the line. During Thompson's period in office as Engineer in Chief, 4700kms of line were opened, linking dozens of country centres, Meekatharra to Mullewa, Merredin to Narrogin, Yuna to Woharing, Esperance to Kalgoorlie.

### *Walking Directions:*

City West walk: Continue west along St Georges Terrace to site 14: Norman Brearley pavement marker (1921)

### **16. Samuel Kingsford's mill site**

Mill St was the site of a mill-building effort in 1833 by Samuel Kingsford. Kingsford spent large sums to build deep drains from the lakes (located where the present Fremantle rail line runs) across Wellington St, Murray St, Hay St and St Georges Tce into Mill Lane, as it was then called. The drains ended at a large dam, where Kingsford installed flood-gates to regulate the supply. Unfortunately, there was very little wheat produced in the colony at the time and Kingsford fell ill and never recovered the debts incurred building it.

### *Walking Directions:*

City West walk: Continue west along St Georges Terrace to site 15: James Thompson pavement marker (1925)

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### 17. Leon Goldsworthy pavement marker (1944)

Leon Goldsworthy was born in NSW in 1909 and educated as a mining engineer in South Australia. He was working in WA when war broke out and tried to join the Royal Australian Navy. He was too small, but in early 1941 he was appointed to the R.A.N.V.R. and became a member of the Rendering Mines Safe Section of H.M.S. Vernon; his civilian career had given him a good grounding in bomb mechanisms.

He won the George Medal, the George Cross and the Distinguished Service Cross, and was mentioned in dispatches for a series of bomb disposal successes, including the defusing of bombs underwater, involving 'great courage and devotion to duty'. In 1944 he did a tour of duty in the South Pacific theatre. Goldsworthy was Australia's most highly decorated naval officer of the war. Back in civilian life he became factory manager of an electric sign business in Perth.

*Walking Directions:*

City West walk: Continue west along St Georges Terrace to site 16: Samuel Kingsford's mill site (Mill St)

### 18. Reveley's Mill site (Brookfield Place)

The Old Perth Boys School, and former Perth Technical School stand on the site of WA's first water-powered mill, built by Henry Reveley on the property adjacent to his house. The mill was designed to make use of groundwater; which was drained into a millpond then funnelled down to the mill. Reveley calculated that the mill could grind ten bushels in four hours, using 1,800 gallons per hour (approximately 6800 L/hr), then waiting 20 hours for the pond to refill from the groundwater. Unfortunately Reveley was unable to achieve a continuous supply of water and the mill was never a great success.

In May 1900, the Perth Technical School opened in the Old Perth Boys School building with courses in chemistry, assaying, engineering, art and design, woodwork and metalwork available to both boys and girls. In 1910, the school moved to from the makeshift facilities in which students had initially been forced to work with to an impressive purpose-built technical school next door. Its motto Truth, Beauty and Utility,

emblazoned above the front entry, expressed the era's high hopes for technical education.

*Walking Directions:*

City West walk: From the plaza area, you can see site 19: Brookfield Place.

### 19. Brookfield Place

Brookfield Place is Perth's second-tallest building and was completed in 2012. The 47-storey, 240-metre building was awarded the 2013 WA Engineering Excellence Award for its engineering innovation and creativity.

Brookfield Place was designed with its core on the northern side, creating floorplates completely open to the river and allowing in sensational views to the south. Offsetting a skyscraper's core is often regarded as structurally difficult and a limiting factor for tall buildings, because the core is usually provides the structural mechanism to transfer wind loads down to the foundations.

The solution was an ingenious and eye-catching external bracing system on its eastern and western sides consisting of two centrally braced frames, or CBFs. The external frames form two double tube 'mega columns' with braced H sections at every fourth floor, allowing the building's core services to be reduced to an area that is very slender.

The building's foundations use state-of-the-art seismic protection from earthquakes. The 45cm thick seismic pad is constructed using special wave-dissipating acoustic metamaterials which can reduce earthquake accelerations by an order of magnitude.

The skyscraper set a benchmark for Australian engineering excellence and is said to be the tallest side core building in the southern hemisphere. Not only that, but in the end, the 47-storey tower was delivered 100 days early and under budget, along with an exemplary safety record.



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### *Walking Directions:*

City West walk: Cross back to the north side of St Georges Terrace and continue west to site 17: Leon Goldsworthy pavement marker (1944)

### **20. Sir Russell Dumas pavement marker (1951)**

Sir Russell John Dumas (1887-1975) was a key figure in WA's engineering history, responsible for the construction of many of the water supply dams which feed Perth, as well as Australia's largest dam on the Ord River. As director of works and buildings, Dumas declared that 'engineering is the basis of civilisation' and instigated many bold initiatives to establish the large-scale development that have been an essential part of Western Australia's capacity to contribute to the Commonwealth.

Russell Dumas was born and educated as an engineer in South Australia. He served in the 1st A.I.F. and after the war was an engineer for the River Murray Works 1919-25. Then he came to WA as resident engineer for the Hills Water Supply. The Comprehensive Water Supply Scheme which supplied water to the agricultural districts and extended South-West irrigation schemes was carried out under his direction. In particular, he was responsible for the design and construction of Canning Dam and supervised the districts including the Wellington Dam. This was work in the tradition of O'Connor.

From 1942-53 he was Director of Works and Buildings and then Coordinator of Works and Industries. During this time his department built power stations at South Fremantle and Collie, bulk handling facilities for wheat at North Fremantle, numerous suburban and country schools, and harbour development work at Bunbury, Fremantle and Albany.

A keen advocate of northern development and industrial expansion his vision and energy had great impact on the scope of government policy. He and Works Minister David Brand worked together closely in negotiation with the Anglo-Iranian Oil Co in 1951 to secure an oil refinery for WA at Kwinana. This was effectively the prelude to the later industrial boom. In retirement, he served as a member of the important Industries Advisory

Council. He was created K.B.E. in 1964 and died in 1975 at the age of 88.

[see also site 4: Dumas House]

### *Walking Directions:*

City West City West walk: Continue west along St Georges Terrace and cross at the pedestrian signals to reach site 18: Reveley's Mill site.

### **21. Perth's first traffic lights**

On 19th December 1954 the first traffic lights were turned on in the Perth CBD at the intersection of William St and St Georges Terrace.

The Advertiser reported that "traffic police were kept busy today ... When all police were busy correcting offending road-users, mainly pedestrians, many motorists crossed against the red lights."

### *Walking Directions:*

City West walk: Continue a few paces further west along St Georges Terrace to site 20: Sir Russell Dumas pavement marker (1951)

### **22. First automatic telephone exchange**

Central Exchange in Murray St Perth was the first automatic telephone exchange in Western Australia. It replaced a manual exchange which was housed in the GPO (Treasury Buildings), and the exchange was cut over on 26 September 1914 with 3200 subscribers.

At the time, the Perth Central Exchange was the biggest in Australia, the first to service a central business district and installed only two years after Geelong (the first public automatic exchange in Australia).

Central continued to serve a substantial part of the Perth CBD for seven decades. It was finally decommissioned in 1987 and the building eventually on-sold. It is now used as business offices but externally appears almost the same as it did a century ago.

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### *Walking Directions:*

City Central walk: Cross over Murray St and head east to site 23: No 2 Electricity Substation

### **23. No 2 Electricity Substation and fmr Professional Societies' Rooms**

No. 2 Substation, Murray Street was constructed in 1914 as part of changes to the electricity system of Perth in response to its rapidly increasing population. It was one of four electricity substations constructed by Perth City Council to operate with the new East Perth Power Station (1916), the first centralised electricity supply in Perth, and continued to operate as an electricity substation into the twenty-first century.

The Perth City Council's unwillingness to completely relinquish control of electricity production and distribution for their locality is illustrated in the physical fabric of No. 2 Substation, Murray Street, which originally featured the name Perth City Council in the entablature, despite having been built as part of a State Government centralised electricity scheme.

The erection of No. 2 Substation, Murray Street and installation of the plant was supervised by Merz & McLellan. Merz & McLellan, particularly Charles McLellan, were advisers to the City of Perth and the State Government regarding electricity production and were significant in the decision to centralise and change to alternating rather than direct current.

In 1922, the headquarters of the Perth Division of the Institution of Engineers moved here, to a room on the top floor of the No 2 Electricity Substation. Unfortunately, these rooms were found to be cold in winter, hot in summer, with very hard seats, while the noise of the tramcars in Murray Street severely disrupted meeting proceedings.

### *Walking Directions:*

City Central walk: Continue east on Murray St to site 26: Gledden Building

### **24. Perth Radio 6WF (fmr Westralian Farmers Building)**

In 1924, the Westralian Farmers Co-operative Limited (Wesfarmers) began operating radio station 6WF from the top floor of the company's Wellington Street building. The first manager and chief engineer of 6WF was Wally Coxon, who has been described as "The Father of Radio in Western Australia".

The radio station comprised two studios, the smaller used for news broadcasting, the larger for music and entertainment. The studios were fitted with the latest equipment for the era, with the wall cavities filled with sawdust for soundproofing. Two massive radio towers, each weighing 3.5 tons, were located on top of the building. 6WF was initially a long-wave station with 5 kilowatts of power on 1250 metres, 240 kHz.

The station facilities were installed at a cost of approximately £12,000 and had a broadcasting capacity of 600 miles.

To gain extra coverage for 6WF programs, Wally Coxon also broadcast on the short-wave band, as these radio frequencies can reach vast distances by being refracted back to the earth by the ionosphere (a phenomenon known as "skywave propagation"). Important factors when 6WF was targeting the widely dispersed farming community.

The Australian Broadcasting Company took over five years later in 1929 and Coxon was replaced by the ABC's own engineer from Sydney.

Wally Coxon went on to later support the radio network used by the Royal Flying Doctor Service, building the 'Coxon Communicator' - an inexpensive and efficient radio used at many outposts across the State.

### *Walking Directions:*

City Central walk: Continue west along Wellington St to Shafto Lane, turn left and make your way to Murray St and site 22: First automatic telephone exchange

### **25. No.4 Electricity Substation**

This is one of four original electricity substations that formed the 'Ring Main' of Perth's early electricity supply system.

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For more information, see the entry for site 23: No.2 substation on Murray Street.

### 26. Gledden Building

The Gledden Building was one of the highest buildings in Perth when built and one of the few art deco office buildings constructed. It is a rare surviving example of a thirties era reinforced concrete office building over 40 metres tall.

The building is named for engineer and early mining surveyor Robert Gledden. Gledden was appointed in 1892 as mining surveyor for the Yilgarn Goldfield and also laid out the townships of Coolgardie and Kalgoorlie. Through a series of astute property investments, Gledden amassed significant wealth, retiring in 1900 at the age of forty four and spending much of his time travelling internationally.

On his passing in 1927, Gledden's estate bequeathed 60,000 pounds and the land on which the Gledden Building stands to the University of Western Australia. His will specified the funds were for the encouragement of education in the applied sciences, particularly engineering, surveying and mining. The Gledden Building was constructed by the University of Western Australia as a way of raising funds for two Gledden Scholarships, and also included meeting rooms on the top floor of the building where the Perth Division of The Institution of Engineers met for twenty years from 1938.

Robert Gledden's legacy had a significant impact on engineering education through his bequest. The Gledden Scholarships, including the 'Gledden Tour' travelling scholarship, have supported many engineers.

#### *Walking Directions:*

City Central walk: Turn left (east) down Hay St through to the end of the mall. Continue along Hay St past the Perth Town Hall then turn right into Cathedral Ave. Continue to reach the final destination of this walk, site 36: St George's Cathedral.

### 27. Horseshoe Bridge

As the gold rush hit Western Australia in the 1890's Perth experienced its first population and construction boom. Unconstrained growth around the central railway station saw the area develop into a "great area of yards and squalid sheds of ill-conceived contrivance". With up to seven sets of rail tracks the area had become very difficult and dangerous to cross by horse or on foot. However, the major challenge faced by the Public Works Department was that close proximity of the buildings at either side of the railway made it very problematic to construct a straight bridge.

An ingenious engineering solution to this came in 1903 with the construction of horseshoe-shaped bridge. Robert Howard, a draughtsman working for the Public Works Department, drew up plans for a horseshoe bridge. The estimated expense was originally £25,000, but it was delayed for a couple of years and eventually cost an enormous £40,000.

The completion of the bridge allowed for easier vehicular and pedestrian traffic over the tracks and reinforced William Street as one of the main access routes into Central Perth from the north. In the early 1920s, a tram line was laid over the horseshoe Bridge, connecting Osborne Park and Leederville with central Perth via Newcastle Street. The bridge has acted as a major link between the city centre and the expanding northern suburbs and remains in use.

One of the enduring features of the bridge was an 114,000 litre water tower built in 1896 for the Railway authority at the intersection of Wellington and William Streets to feed the thirsty trains. It was incorporated into the final bridge design. When steam trains ceased in 1971 the tower had another lease of life as an advertising hoarding. Completely rebuilt in the 1980s, the tower was finally demolished in April 2014 as part of the City Link project.

The bridge is one of the oldest surviving bridges in central Perth and is now a significant part of Western Australia's built heritage.

#### *Walking Directions:*

City Central walk: Cross Wellington St at the lights and continue west to site 24: Perth Radio 6WF (fmr Westralian Farmers Building)

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### 28. Perth Central Railway Station

The original Perth Central Station was designed by Richard Roach Jewell, the same architect of other famous city buildings such as Perth Town Hall, and Pensioners' Barracks. After 10 months of construction, the station was opened for public use in 1881, along with the entirety of the Fremantle-Guildford railway line. The station was designed with a single through platform, with bay platforms to the east and west. This design proved to be inadequate for the expanding rail network, so the decision was made to construct a new, larger station to the immediate south of the original one.

The new Perth Railway Station was designed by Government architect and engineer George Temple-Poole in the neoclassical style similar to his other works including the State Buildings near Point Zero. The new station was built in the large space between Perth Central Station, and Wellington Street, allowing the old station to remain in operation throughout construction. The new building was completed by 1893 and included offices for the Western Australian Government Railways in the second level. The old Central Station was then demolished.

Perth was first linked by rail to Adelaide and Sydney in 1917 by the Trans-Australian Railway. In joining eastern and western Australia, it provided a physical link which was to be of major commercial and strategic importance and which improved immeasurably the convenience and comfort of interstate travellers. The railway was also a symbol to all Australians of the bonds which had bound the colonies together in Federation.

When the Trans-Australian Railway commenced operation, no other railway in the world was so completely self-contained. Commonwealth Railways ran its own farms and stores, and provisioned by rail the small communities along the line for which all the social and service infrastructure was provided. The railway had a number of unique operational features including the longest straight stretch of track in the world (478 km 193 m), and for twenty years from 1933, the longest run undertaken by coal burning steam locomotives, 867 kilometres from Cook to Kalgoorlie.

#### *Walking Directions:*

City Central Walk: Head west along Wellington St to site 27: Horseshoe Bridge

### 29. Engineering an artwork

Engineers don't only create bridges and buildings. Many of the major artworks around Perth were only made possible through the skills of the engineers who create ingeniously hidden structural details and innovative materials to help deliver each artist's vision.

The 29-metre tall 'Spanda' artwork represents the ripples of the Swan River, linking with the elliptical orbits of the atoms in the land and the planets and galaxies in the sky. The Danish artist, Christian De Vietri, collaborated with Australian engineers to find a design solution that delivered De Vietri's vision of a thin and elegant form, but with a rigidity that could withstand the most extreme weather conditions. Artwork engineering is a highly collaborative end-to end process, starting from structural design, 3D modelling and material selection through to safety certification, manufacturing and installation.

#### *Walking Directions:*

City West walk: Continue across the pedestrian bridge and the island to site 31: Perth foreshore reclamation

### 30. Elizabeth Quay Pedestrian Bridge

The Elizabeth Quay pedestrian bridge was the winner of a WA Engineering Excellence Award in 2016. The bridge spans between the western Williams Landing and the new island in the east, providing increased opportunities for people to interact with the Swan River. It is 22m high, 5m wide and suspended over the inlet with a 5.2m current mean clearance. Two 45m spans connect in the middle, with the bridge's arches sweeping down towards the water to rest on concrete piers supported on piles socketed into the rock bed.

While cable-stayed arch bridges are becoming a more common solution to bridge a gap in an elegant light-weight method, the excellence award recognised innovations in the design process, using highly collaborative digital workflows to connect the artistic architectural vision with dynamic structural analysis models to optimise and rationalise the complex bridge form in a short time frame.

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### *Walking Directions:*

City West walk: From the centre of the pedestrian bridge, pause to view site 29: Engineering an artwork, associated with the 'Spanda' sculpture.

### **31. Perth foreshore reclamation**

During the early period of European settlement, the Elizabeth Quay area operated as the Perth Port and was the focal point for transport, commerce and leisure in the city. In the late 19th century construction of the Perth railway station on Wellington Street removed the need for Perth Port and made the river foreshore available purely for recreational pursuits. As a result large scale works were undertaken to reclaim portions of the foreshore to create a linked series of public open spaces.

The former Esplanade Reserve was the site of the first major reclamation project on the Swan River. The reclaimed land witnessed the State's proclamation of self-government in 1890 and was developed as Perth City's first dedicated recreational zone and has been the site of many recreational uses and community gatherings since its inception, including the first ANZAC day parade in 1916. Foreshore reclamation continued through the early 20th century as far as the Causeway with the creation of Riverside Drive and the Narrows Interchange.

### *Walking Directions:*

City West walk: Make your way through Elizabeth Quay precinct to site 32: The Bell Tower

### **32. The Bell Tower**

The Bell Tower was constructed in 1999 to house 18 bells given by the people of Britain as part of Australia's Bicentenary celebration. The twelve heaviest bells came from one of London's most famous churches, St Martin in the Fields in Trafalgar Square, having been in existence from before the 14th century, although recast on several occasions. They are one of the few sets of royal bells (Buckingham Palace is in the Parish of St Martin in the Fields) and are the only ones known to have left England.

The St Martin-in-the-Fields bells had rung out to celebrate many historic events such as, England's victory over the Spanish Armada in 1588, The World War II victory at El Alamein in 1942, ringing in the New Year at Trafalgar Square for more than 275 years, celebrating the coronation of every British monarch since King George II in 1727, the homecoming of Captain James Cook after his voyage of discovery in 1771.

An additional six bells were cast with a donation of copper and tin mined in Western Australia. The 18 bells have a combined weight of about nine tonnes, and, when rung, exert considerable forces on the support structure. Engineered by Arup to achieve the required rigidity, the six-storey bell chamber was made with reinforced concrete, cast in situ. Soundproof louvres and doors are used to muffle the sound or direct the noise towards the city or the river as required.

The design of the building reflects the boat building history of the Barrack Square area. The design concept was also deliberate in an attempt to demonstrate the state-of-the-art design, engineering and construction of the time and be representative of Western Australia's skills in these fields.

In 2018, a sixth bell was cast in Western Australia to commemorate the World War I Armistice. At 6.5 tonnes, this bell is now the heaviest bell in Australia.

### *Walking Directions:*

City West walk: Make your way through the Supreme Court Gardens and under the tunnel between the Supreme Court buildings to the final location of this tour, site 33: Perth's oldest remaining building

### **33. Perth's oldest remaining building**

The Old Court House was designed by Henry Reveley, first civil engineer to the Swan River Colony, and built in 1836. The design is in the classical Greek revival style.

Reveley's specification for the building survives. It specified [lime]stone footings bedded in lime mortar, 4ft deep (1,220mm) by 3ft wide (915mm). The walls were solid brick and stone, 14in thick (355mm) not including the plaster layers. A stone-filled drain was to be constructed around the entire perimeter of the building. The roof was supported by

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timber trusses of an unusual design similar to a queen post truss system, specified by Reveley in drawings. The roof was covered with timber shingles and lined by weatherboards on the interior side. The timber floor joists were supported on the external walls and on two parallel stump walls constructed below floor level.

Court sessions commenced in January 1837. The building was also used as a church, with the first service held on Good Friday in that year. Church services continued until St George's Church (later made into a Cathedral) was completed in 1845. The building was also used as a school in its early years. When the court was sitting the students had to work quietly in the upstairs jury room. Other uses for the building included for public meetings, as an immigration depot, and for rehearsals and concerts

The Old Court House was one of a number of government buildings constructed by Reveley in Perth and Fremantle during the early years of the Swan River Settlement. His earliest surviving building is the Roundhouse in Fremantle. In the City of Perth, none of Reveley's other buildings survive, making the Old Court House the oldest surviving building in the City of Perth.

The building now houses the Law Museum.

### *Walking Directions:*

City West walk: This is the final destination of this tour. To return to Point Zero, make your way through the Stirling Gardens to St Georges Terrace and cross at the lights.

To continue on to the City Central walk, remain on the south side of St Georges

## 34. State Buildings

The State Buildings, also known as the Old Treasury Buildings or, more correctly, the Central Government Offices, are three interconnected buildings with a long history of public uses, including as a post office, treasury, telephone exchange, police cell block, the office of the Premier and Cabinet and the office of the Public Works Department. Engineer-in-Chief C.Y. O'Connor had offices in the buildings during the 1890s.

The first section of the building, on Barrack Street was designed by Richard Roach Jewell and was built in 1875. Since then, the buildings have been remodelled, extended and

redeveloped a number of times over the years, with the current stylistic features most influenced by architect and engineer George Temple Poole's designs from 1889. Several engineering innovations have been present throughout the life of the buildings, although few have been retained to today. An interesting feature still visible in the basement is the use of corrugated steel sheeting as permanent formwork for the concrete floor above - with secondary functions to secure and fireproof the police holding cells and government strong-rooms.

In 1897, a new three-storey wing was constructed, with a hydraulic passenger lift and machinery in the basement supplying water pressure to propel the elevator. The top floor of the new wing was occupied by the Railway Construction branch of the Public Works Department.

By 1901, the General Post Office had one of the three new electric elevators installed in Perth, and for a short period Western Australia reportedly had more electric lifts than the whole of the rest of Australia.

The recent restoration and redevelopment of the State Buildings required significant input from structural and heritage engineers for works to stabilise the site foundations, mitigate corrosion of structural steelwork in the balconies and upgrade the seismic capacity of the building to comply with current Australian Standards design codes.

### *Walking Directions:*

City West walk: Continue west along St Georges Terrace to William St and site 21: Perth's first traffic lights

## 35. Earthquake engineering (McDonalds building)

If you look carefully at the corner window in the upper floor of the McDonalds building, you can spot a series of cracks which have been poorly patched. These cracks were sustained during the 1968 Meckering Earthquake, a magnitude 6.5 quake with its epicentre near the town of Meckering about 130km east of Perth.

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At Meckering, the ground ruptured along a 37km long faultline, while in Perth, buildings cracked and walls and ceilings collapsed amid a deep rumbling; pierced by the crashing of plate glass as the quake shook the city for about half a minute.

The earthquake was the first time that ground rupture had occurred in Australia, and it was a wake-up call for engineers who had previously believed Australia was not susceptible to any significant earthquake risk.

Following the Meckering quake, Western Australian engineer Charles Bubb spoke at technical symposiums and lobbied his professional colleagues to form the Australian National Committee on Earthquake Engineering. As chair of the committee, Bubb then guided its members to develop a structural design code to ensure Australian buildings were resilient to earthquake loads.

Finally, in 1979, eleven years after the Meckering earthquake, Australia's first Earthquake Code – Australian Standard 2121 was published. This was a great achievement for the code team and recognition by the engineering profession that Australia could no longer be assumed an earthquake free zone.

### *Walking Directions:*

City Central walk: Continue west through the Murray St mall and on through Forrest Place to site 28: Perth Central Railway station on Wellington St.

## 36. Heritage Engineering for St George's Cathedral

The St George's Cathedral is an interesting case study in the art and science of heritage engineering - a specialist field of structural engineering that combines heritage considerations with structural safety requirements.

The cathedral was built during the 1880s with brick walls, a timber framed roof with slates and a timber floor. However, by 1932 concerns had been raised about the safety of the bell tower when the bells were rung, and again in 1966 about fretting of the brickwork. CSIRO scientists had estimated the life of the building to be 20 to 30 years and advised that the bell tower was in danger of collapse. In 1968 the building was damaged by the Meckering earthquake and in 1973 some bricks dislodged when the bells were rung. In an

attempt to alleviate this problem, a new ring of bells, almost half the weight of the old ones, was installed in 1975.

Finally in 2000, a team including eminent heritage engineer Ian Maitland was appointed to undertake major restoration work. The works were required to strengthen the building to meet current earthquake standards for existing buildings and extend the life of the building. As a heritage structure, it was important for an absolute minimum of the work to be visible.

As with many heritage structures, the few drawings available were very basic, which meant key measurements and materials were unknown. Before developing restoration solutions, the entire site had to be surveyed and the brickwork was tested for strength and the mortar for composition.

With the test results and an old brickwork design code, the original design parameters were determined and a structural analysis of the building could be undertaken. The investigations had revealed defects in the walls including cracking, de-lamination of arches, areas of overstress, falling damp and erosion. Defects were also identified in the jarrah timber roof trusses – members split or over-stressed and joints loose or over-stressed.

To remedy these issues, the walls were strengthened with hidden helibar reinforcement, a poulticing technique managed dampness and some bricks were replaced. Roof members were strengthened with bolted steel plates and the problems of inadequate connections, stability of elements and transferring earthquake forces through to the ground were addressed in various ways, including the installation of steel bracing through the crossing.

### *Walking Directions:*

City Central walk: This is the final destination in the City Central walk.

To continue on into the City West walk, return to St Georges Terrace and head west to site 36: State Buildings

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### 37. Council House

Council House is an 11-storey building that was officially opened by Her Majesty Queen Elizabeth II on 25 March 1963. Civil engineer William Green was Perth City Council's town clerk from 1945 and is credited with being the driving force behind the original project. It has been reported that Green was behind every important decision taken by the council. As an engineer he was quick to grasp essentials, as an architect he had a flair for seeing things as a whole, and as an administrator he believed in thorough preparation and research. He was either the designer or the adviser for practically every building constructed by the city council between 1944 and 1966.

The structural engineering for the innovative steel-framed building was undertaken by D.H. Fraser, Consulting Engineers. As principal consulting engineer, Don Fraser developed the conceptual design while a young civil engineer, Tom Huuk completed the detailed design work.

The major engineering challenge was the ground floor level, which was designed to give the impression that the building is floating. With only two columns per bay going across the building, all the floors above the first floor level had to be picked up on massive welded steel girders, sitting on the two columns with their ends cantilevered over on each side to carry the building's façade on the north and south sides. The challenging design involved some critical welding of the plate girders and required minute checking.

While Council House is now regarded by experts as the best example of modernist architecture in Perth, there were periods when its future was in serious jeopardy. In the 1990s, just 30 years after its grand opening, there was a push to demolish the building, to return the area to its historic style of architecture. After fierce public debate, it was instead recognised that modern structures can hold heritage value and was heritage listed in 2006.

*Walking Directions:*

City Central walk: Return east along St Georges Terrace until site 39: Government House comes into view.

### 38. Henry Reveley pavement marker (1837)

Henry Willey Reveley was Perth's first engineer. The son of an architect, Reveley grew up in a circle of intimates which included philosophers Bentham and Godwin. He was a close friend of the poet Shelley, and saved Shelley's life from drowning in the Arno. Educated in Italy as engineer and architect, he was an eleventh-hour addition to the roll-call of Western Australia's founding fathers, being recruited by Stirling as Civil Engineer to the colony when the *Parmelia* called at Capetown, where Reveley had been engaged on similar duties.

From 1829 to 1838 he was responsible for the design and construction of all public works and buildings including jetties, roads and bridges, barracks, offices and the first Government House. Imported timber was attacked by heat and termites and local materials had yet to be tested; skilled labour was scarce and many of the early buildings were hardly more than sheds. Of his permanent buildings, constructed in a simplified Georgian style in keeping with the Colony's meagre resources, only the Round House in Fremantle and the Old Court House in Perth survive. His scheme for a Fremantle breakwater was beyond the colonial means and his flour mill built of local materials failed for lack of water. Reveley did not get on well with the colonial establishment and left the Swan River in 1838.

*Walking Directions:*

City Central walk: From here you can see site 37: Council House.

### 39. Government House

In 1834, the current Governor James Stirling tasked Henry William Reveley, Western Australia's first civil engineer, with designing the new Government House. Initially, the architecture of the first Government house was based on one of Reveley's previous projects, the Old Court House located in Stirling Gardens. However due to a lack of funding, the building unfortunately did not live up to Stirling's expectation with a leaking roof, damp walls termites in the flooring, shortage in accommodation and the inability to facilitate large events for the Governor.



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It wasn't until 1857 that Captain Wray of the Royal Engineers presented plans to build a new Government house in a classic Revival style for Governor Arthur Edward Kennedy. This plan was then modified to become a more impressive building by the Lieutenant Colonel Edmund Henderson of the Royal Engineers and Comptroller of Convicts. Building commenced in 1859 and only finished in 1864, delayed by ongoing changes to the design due to indecision and difficulties in sourcing materials from England.

Engineers have also contributed significantly to political life in Western Australia. John Sanderson (2000-2005) and Ken Michael (2006-2011) were appointed as the 29th and 30th governors of the state, respectively.

### *Walking Directions:*

City Central walk: Return back across St Georges Terrace to site 40: Harold Clough pavement marker on the corner of Pier St.

### **40. Harold Clough pavement marker (1983)**

Harold Clough, the son of John Clough and Lucy Haynes, both from Victoria, was born in 1926, and attended Nedlands primary school and Scotch College in Perth. Harold passed his leaving exams at age 16 but was too young to enter Duntroon Military college so worked for a year as Junior Mail Clerk at AMP insurance company.

In 1944 he decided to become an Engineer when the University of WA offered a war time course of three years resulting in a BSc degree. This was subsequently upgraded to a BE with first Class honours in Mechanical Engineering in 1950. In 1951 Harold was awarded a Fullbright scholarship to study at the university of California Berkeley where he obtained a Master of Science in Industrial Engineering. Harold returned to Perth in 1954 and joined his father's building company, originally called J.O. Clough & Son, now known as Clough Limited. The first major contract was the first 'sky scraper' building in the city which was the National Mutual building in the Terrace, completed in 1959. Next came the Narrows Bridge contract, which was a joint venture with the Danish company Christiani & Nielsen, and which was also completed in 1959.

The joint venture strategy was repeated successfully with other large contracts throughout the state. First, contracts in the iron ore mining sector in the north, followed

by expansion into the oil and gas sector including offshore works. Harold's own interests moved away from straight engineering into more business related areas. Harold retired as Chairman of Clough Limited in 2001, having collected a host of awards during a distinguished engineering and business career.

### *Walking Directions:*

City Central walk: Continue east along St Georges Terrace to site 41: John Roberts pavement marker (1989)

### **41. John Roberts pavement marker (1989)**

John Charles Roberts was born in Perth in 1933 and attended Guildford Grammar School. He is a sixth generation Australian, tracing his ancestry back to the First Fleet.

In 1962 he formed the building company Multiplex Constructions Pty Ltd. From his first project, the Laporte Titanium Effluent Pipe Line across the Australind Estuary, he has built the company up to become the largest privately owned company in Australia.

During the 1980s, Multiplex constructed over \$1.5 billion worth of buildings in Western Australia including: the Metropolitan Water Centre, Alexander Library Building, Burswood Casino, the 50 level Bankwest Tower, Forrest Chase, Westralia Square, the 51 level Central Park Plaza and numerous Perth shopping centres, office blocks and hotels. Many of these buildings won engineering, construction and design awards. Recently Multiplex has also undertaken significant environmental projects including the remediation of the old East Perth Gasworks site and the creation of Claisebrook Cove in East Perth.

Multiplex has also constructed major buildings in other Australian cities. In 1996 Multiplex became the successful bidder for the Stadium Australia contract for the Sydney 2000 Olympic Games. John Roberts has also made a contribution to the conservation of Australia's heritage through the restoration of a number of historic buildings.

### *Walking Directions:*

City Central walk: Continue east to site 42: UWA original Irwin St site.

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### 42. UWA original Irwin St site

The University of Western Australia was originally located in the centre of Perth, on Irwin St. A T-shaped jarrah building constructed in 1913 provided the University's original accommodation on this site.

Professor AD Ross, Foundation Professor of Mathematics and Physics commented that:

"...the first building we got was certainly original in more senses than one. It was a jarrah shed, 110 feet long by 20 feet wide ... We estimated that the building would be ready for a start on the 16 March, then 21 March, then 23 March, and finally it must be 31 March. Members of staff, at the risk of their lives, would go in and pin up notes on doors: 'Department of Geology' or the like. Since one of the little rooms had already been commandeered for the janitor, the telephone, electric switchboard, brooms, mops and buckets, it was evident that eleven departments must share six rooms."

The first professor of Mining and Engineering was Hubert E. Whitfeld, from 1913 to 1927. He was also the University's first Vice-Chancellor, on a part-time basis until 1915, and again from 1925 to 1927. He went on to become the University's first permanent Vice-Chancellor (1927 – 1939).

By 1914, the University was granted permission to use the Crawley Park Homestead to accommodate the Department of Mining and Engineering. The homestead underwent some alterations to meet teaching requirements and the University formally acquired the property in 1921. It was later renamed 'Shenton House' in honour of Sir George Shenton, who had once owned it.

The Old Engineering Building situated next to Shenton House, was the second permanent University building constructed on the Crawley site. It was designed by the Public Works Department and completed in 1927 at a cost of £8,825.

The original Irwin Street Building was put to various uses during the ensuing years, its occupants including the Faculty of Law, Departments of Botany and Psychology, Extension Services, Festival of Perth and the University Radio. Until in 1982 the University Senate adopted a recommendation that the Irwin Street Building be reconstructed and placed on James Oval where it 'could be used as a meeting place and a cricket pavilion.'

The Irwin Street Building was fully restored and officially re-opened on 15 February 1987. The building currently provides accommodation for the Convocation Council Room, the University Archives and the Cricket Club. Both the National Trust and the Australian Heritage Commission have it listed as a Heritage Building.

*Walking Directions:*

City Central walk: Continue east to Victoria Avenue and site 48: Statue of John Septimus Roe.

### 43. Former Electricity and Gas Department

The Perth Municipal Gas and Lighting Act of 1911 paved the way for the Perth City Council to purchase the Perth Gas Company, which had produced coal gas for Perth since 1886, and had operated the state's first power station in Wellington Street in 1894, supplying 110 volts direct current to the Perth Town Hall, Wesley Church and the paper manufacturers Wigg & Son in King Street.

The intervening years had seen significant competition and controversy over the provision of gas and electricity, and in particular whether street lighting should be gas or electric. The commencement of the Perth Tramways Company in 1899 further complicated the electricity supply market.

Following the municipalisation of the Perth Gas Company, the managing engineers of the Electricity and Gas departments, Herbert Broadbent and James Andrew, respectively, made recommendations to the Mayor that Perth's power supply should be centralised to a single site and converted from direct current (DC) to alternating current (AC) to improve the network reliability and enable efficient transmission to the spreading suburbs of the city.

As a result, in 1916, the East Perth Power Station was completed, initiating the centralised electricity scheme for Perth and becoming the first government in Australia to take on the public production of electricity.

In June 1920, the Electricity and Gas Department moved into the building at this site. The engineering department was located on the second floor and workshops were

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constructed at the rear of the building to bring all of the department's stores, garage, repairs and fittings on-site. At the time, the city served approximately 13,000 electricity customers and 4,300 gas customers.

By 1946, with the end of World War II, consumers were driving a sharp increase in electricity demands and the newly formed State Electricity Commission (SEC) took control of all power generation, transmission and distribution in the metropolitan area. The City of Perth Electricity and Gas Department was absorbed by the SEC in 1948.

*Walking Directions:*

City Central walk: Continue west to Site 35 on the North East corner of Murray and Barrack Street.

### 44. No.1 Electricity Substation

This is one of four original electricity substations that formed the 'Ring Main' of Perth's early electricity supply system. Note entry points on the upper floor for overhead wires. Site still used by Western Power for a city depot.

For more information, see the entry for Site 23: No.2 Electricity Substation on Murray Street.

### 45. Central Perth Fire Station

The No 1 Fire Station was the first purpose-built fire station in WA. It opened in 1901 and continued in operation until 1979.

Before No. 1 Fire Station was built in 1900, the Fire Brigade operated from the Undercroft of the Town Hall on Barrack Street. Fire brigades in Western Australia expanded rapidly after the Fire Brigades Act of 1898. There were just 21 in 1902, but twenty years later this number had doubled.

The expansion of the service from 1898 meant the Central Fire Station under the Town Hall was no longer sufficient, so a new station was planned on the corner of Murray and

Irwin Streets. Designed by architects Cavanagh and Cavanagh, the new building was Romanesque in style, with solid rock-faced stone walls and a red-tiled roof.

The large engine room had three exits and held two large steamers and two hose carts, which doubled the equipment with which the brigade had previously been working. When a call was received, an officer pressed a button, which set the alarms ringing, flooded the building with electric light, and opened the trap doors in the ceilings to clear the sliding poles.

Today No. 1 Fire Station has been converted for use as a Fire Brigade Education and Heritage Centre, and is a popular museum and education centre, visited by both schools and the public. The museum includes a range of historical fire-fighting vehicles and displays on other natural hazards in WA, such as bushfire, storms, cyclones, tsunami and earthquake.

Words from Heritage Perth

*Walking Directions:*

City Central walk: Continue west along Murray St to site 43: Former Electricity and Gas Department

Detour option: Make your way through the hospital grounds to see site 44: No 1. Electricity Substation then return to Murray St (100m).

### 46. William Hancock (RPH Museum)

William John Hancock (1864-1931), electrical engineer and radiologist, was born on 2 May 1864 in Dublin, eldest son of William John Hancock, actuary, and his wife Annette Dickson. He studied engineering for two years at the University of Glasgow under his uncle by marriage, Professor James Thomson, whose brother became Lord Kelvin.

After experience with the Dublin Telephone Exchange, Hancock came to Western Australia in 1886, as superintendent of telephones. He installed the first line between Government House and the Colonial Secretary's Office in 1886 and the Perth exchange in 1887, and supervised the construction of the Perth to Fremantle line. In 1890 he was appointed superintendent of telegraphs, and was responsible for the extension of lines to

## PERTH'S ENGINEERING HERITAGE – WALKING TOUR GUIDE

the goldfields and the remote north. There were difficulties due to the distance, termites, lack of water, heat, bushfires and damage by Aboriginals.

Hancock became government electrical engineer in 1894, a post he retained until his poor health forced his retirement in 1922: he supervised all electrical works in Western Australia, including submarine cables and tramways.

Röntgen's discovery of X-rays was published in 1895, and Hancock obtained the apparatus from London and demonstrated its use in Perth in August 1896. The Perth Public Hospital allocated him a small room and appointed him honorary radiographer in 1898, establishing the first radiography unit in Australia. For the next twenty-two years Hancock worked as an engineer by day and contributed his services and equipment to public patients on several afternoons and evenings each week: it is estimated that he handled over 30,000 X-ray exposures.

His apparatus and skills were invaluable in detecting bullets and shrapnel in wounded returned soldiers, but the danger of prolonged exposure to bare X-ray tubes was not initially understood and by 1903 Hancock had suffered mutilations and ulceration to his hands. He was a semi-invalid on his retirement, although he continued as honorary consulting radiologist to Perth Hospital until 1930.

The Royal Perth Hospital Museum still displays a box containing the first ever x-ray equipment in Australia. Imported from France by Dr W. J. Hancock, the Cold Cathode X-ray tubes assisted in examining patients in the hospital in the early 1900's.

### *Walking Directions:*

City Central walk: Continue west along Murray St to site 45: Perth Central Fire Station

## 47. Heritage engineering for St Mary's Cathedral

Since the first foundation stone was laid in 1863, the St Mary's Cathedral has undergone a series of dramatic transformations to expand and strengthen the structure. The original structure was designed in the Norman Gothic style, with walls built from clay bricks and a single bell tower.

A second phase of construction during the 1920s saw the addition of a new sanctuary and transept built from stone, but retaining the original church as the nave as the economic pressures of the Great Depression set in. By the end of the century, growing concerns about the structural integrity of the building, including falling damp, cracking in the walls and floor, a crumbling bell tower and structural weaknesses, lead to the initiation of a third phase of construction, starting in 2006. These most recent works not only significantly expanded and restored the cathedral, but also offer an interesting case study in the specialist field of heritage engineering.

The new design called for the complete demolition of a section of the nave and part of the western wall of the transept, to allow the construction of a larger assembly area as well as new basement level facilities. This required careful design of a temporary support structure to allow jacking of the upper stone walls and roof of the transept while the new structural steelwork was put in place..

A second spire was added to the northern side of church, of a deliberately different design to the original spire because of a Heritage Council stipulation that the new spire not "shamelessly mimic" the existing one.

### *Walking Directions:*

City Central walk: Head west along Murray street to site 46: William Hancock (RPH Museum)

## 48. Statue of John Septimus Roe

This statue commemorates Western Australia's first surveyor-General, John Septimus Roe. Born in 1797, Roe entered the navy in 1813. From 1817 to 1825 he was master's mate in the N.S.W. surveying service which included extensive surveys of the Western coast.

In 1827 Roe was appointed to the Hydrographic Office in Britain but, two years later, was offered the post of Surveyor-General at the new settlement of Swan River in Western Australia.. Lent by the Admiralty for an active forty years, he retired in 1870, his influence in the development of Western Australia immense.

## PERTH'S ENGINEERING HERITAGE – WALKING TOUR GUIDE

In 1830 and 1831 he laid out the town sites of Perth and Fremantle and the lines for roads, charted harbours and anchorages. He struggled almost single-handedly to survey and allocate land fast enough to keep pace with the demands of the boat-loads of new settlers, and as well leading sixteen overland expeditions between 1830 and 1849. As Surveyor-General he was a member of the colony's executive and legislative councils, as a private citizen he was a leader of the Mechanics Institute and a leading land-owner - "Sandalford", the Roe estate, is still family property. He and his wife gave 13 children to the colony. He retired in 1870 and died in 1878. One of his last entries in his diary before retirement wisely observed: 'I have not been an idle man in my generation'.

Roe Gardens, appropriately, is a memorial to him in Kings Park since he is credited with setting aside Mount Eliza as public land.

### *Walking Directions:*

City Central walk: Cross Adelaide Terrace and continue south down Victoria Ave to site 49: WA's first airport (Langley Park)

### **49. WA's first airport (Langley Park)**

Norman Brearley's airline, Western Australian Airways (WAA), began the first airline operations in Australia in 1921 (a year before Qantas), based at Langley Park.

When flying one of his two bi-planes over the city of Perth in late 1919, Brearley noticed a rectangular patch of flat ground next to the river, extending east from Victoria Avenue. He enquired about using this land as an airfield, and Michael Durack invited Brearley to build a hangar at the foot of his property at 263 Adelaide Terrace. Even though it was public land, and without official permission, Brearley accepted.

At that time, the field had only recently been formed through land reclamation next to the Swan River, and was not named Langley Park until 1938 and was only one third of the length it is today. Brearley began conducting charter and joy flights from country towns all over WA, from Albany in the south, to Onslow in the north, and Kalgoorlie in the east. As there were no airfields and very few cars, he landed on bush tracks or roads.

In 1921, Brearley was contracted to operate Australia's first scheduled airline service - a weekly passenger and mail air service between Geraldton and Derby in the Kimberleys, where the landing strip was the swamp flat at low tide.

He ordered six Bristol Tourer aircraft and set about establishing the first airline in Australia (and the Southern Hemisphere), Western Australian Airways. On the afternoon of Saturday 3 December 1921, several thousand people gathered at Langley Park for an inauguration ceremony by the Governor of WA.

The next morning, three Bristol Tourers took off from Langley Park bound for Geraldton, but tragically, one of the aircraft crashed near Murchison House Station, killing both men. On inspection, Brearley found many of the airfields to be unsafe, and suspended services until improvements could be made, resuming in February 1922.

In 1923, the Federal Government agreed to extend the airmail service to Perth, despite protests from railway operators. Perth's first official airport was opened on the south-western part of the Maylands peninsula and Brearley moved his hangars from the unofficial airport at Langley Park, which he had used since 1920, to Maylands Aerodrome. On 15 January 1924, the first WAA aircraft on the north-west service landed at Maylands, ending an interesting era at Langley Park.

### *Walking Directions:*

City Central walk: Walk east through the park or along Terrace Rd to site 50: Sewage Pumping Station No. 2

### **50. Sewage Pumping Station No 2**

This sewage pumping station was one of three constructed in 1914 as part of the original sewerage scheme for Perth under the direction of Hugh Oldham, Engineer-in-Charge of the Metropolitan Water Supply and Sewerage. The building includes a 'gentleman's public toilet'. The other two were Mill St and the Causeway, but all three have now been replaced by the Central Perth pump station near the busport.

## PERTH'S ENGINEERING HERITAGE – WALKING TOUR GUIDE

### *Walking Directions:*

City Central walk: Head up Hill Street 2 blocks to site 51: The Engineering Gold Rush (Perth Mint)

City East walk/cycle extension (8km): continue along Langley Park / Terrace Rd and Ozone Reserve to site 55: Sewage Pumping Station No.1

### **51. The Engineering Gold Rush (Perth Mint)**

In Western Australia, gold was first discovered in commercial quantities at Halls Creek in 1885, beginning a period of significant population growth and prosperity for the state. By 1890 the colony of Western Australia had been granted 'responsible government', and the first State Premier, John Forrest, had a great passion for improving rail, roads, communication, port and navigation infrastructure. Between 1901 and 1911, gold averaged 75% of WA's export earnings and the population had grown nine-fold since 1885. The new prosperity drove an 'Engineering Rush' with many infrastructure projects being completed between 1885-1914.

This period saw a massive expansion of the railway network and greatly improved port facilities at Fremantle and Bunbury, as well as the first wireless station and the first airplane flight in Perth. By 1894 the telegraph network had significantly expanded allowing communication between all mining centres and 1906 saw the construction of Perth's first sewerage system.

A notable engineer, Charles Y. O'Connor, Engineer in Chief in 1891, was pivotal in many projects such as the major Fremantle Harbor, rail, port and water supply expansion projects to accommodate the growing population. 1898 marked the year in which his ambitious Coolgardie Water supply scheme was implemented. Among other developments, the developing economy attracted more engineers, architects and surveyors where the growing local government appointed more engineers to oversee various projects throughout Perth. Public Works Department staff numbers grew from just 15 in 1894 to 874 in 1897.

The dramatic growth in the numbers of engineers and related professionals stimulated the formation of the WA Institution of Engineers in 1909. It also aided the formation of the University of Western Australia, which enrolled its first engineering students in 1913.

The Perth Mint opened as a branch of the Royal Mint on June 20, 1899. The installation of refining, rolling and coining equipment was under the supervision of A V M Ventris. On opening it had an annual capacity of 3 million sovereigns. Between 1899 and 1931 they struck 109 million sovereigns.

### *Walking Directions:*

City Central walk: Head north along Hill St then turn left at Gooderich St. Continue to site 47: St Mary's Cathedral at the top of the hill.

### **52. Lincoln St Ventilation Stack**

During the 1930s, the recently reticulated sewerage system in Perth was affected by high levels of hydrogen sulphide. The engineering solution was to build ventilation towers with motorized electric extractor fans to remove the gas through the tower and far up into the atmosphere. As a result, the Lincoln Street Ventilation Stack, at a height of approximately 38 m with distinctive Art Deco detailing, was built in 1935 and opened in 1941. It is the second tallest sewer tower in Australia.

Unfortunately, acidity of the gases resulted in the corrosion of the exhaust fans and the tower received many criticisms from residents due to the dispersed infamous rotten egg smell of the gas in surrounding areas under certain weather conditions. This led to the sealing of the vents and ultimately the closure of the Lincoln Street Ventilation Stack after just four weeks of operations. The project was managed by the Metropolitan Water supply and Drainage department with the Chief Engineer, Russel J. Dumas. While the Lincoln Street Ventilation Stack was seen as an embarrassing failure (it became known locally as "Dumas' Folley"!), he oversaw other successfully projects such as large dams such as the Waroona, Wellington and Stirling dams, several rural irrigation schemes and the Ord River Scheme.

## PERTH'S ENGINEERING HERITAGE – WALKING TOUR GUIDE

### 53. Roads paved with .. jarrah?

During the 1880s, the jarrah timber trade in the south-west diversified to include the manufacture of paving blocks for roads. Many early experiments with timber paving were conducted in London during the 1880s. Traffic volumes were very high and unsealed roads would rut very quickly under the loads of narrow, iron-rimmed wheels. Granite cobbles were expensive, slippery and noisy when subjected to iron-rimmed wheels. Softwoods and hardwoods from around the world were tested. Softwoods were cheaper to manufacture and install, but their durability was far inferior to hardwoods. It became generally accepted that jarrah was the best timber for paving the roads of the world's busiest cities. A working life of 15 years could be expected for jarrah paving, once the best approaches to laying the blocks had been established.

The trade in jarrah paving, and the jarrah trade in general, was dominated by two railway contractors. Neil McNeil built the South West Railway (Bunbury to Jarrahdale) and Charles and Edwin Millar built the Beverley to Albany Railway. Both diversified into the timber trade. From the late 1880s until the outbreak of World War I, jarrah pavers were exported to European cities including London and Paris, and to the Eastern States.

A few streets in Perth were also paved with jarrah blocks, such as Hay Street in 1900. During the 1970s, excavations on Hay Street revealed jarrah paving directly below the bitumen surfacing. Jarrah paving has also been excavated during construction of the Great Eastern Highway.

*Walking Directions:*

City East extension: continue west along Hay St to site 51: The Engineering Gold Rush (Perth Mint)

### 54. Former brick pits and kilns, Queens Gardens

Queens Gardens are situated on a low lying site near the Swan River. The site was used by colonists for duck hunting and horse racing before the discovery of clay suitable for brick making in the mid 1800's. Clay was dug at the site, and used for production of bricks

which went into several prominent buildings, until c1890 when extraction became difficult and eventually the digging of clay ceased. At this time the site was known as the Brickfields Reserve.

The abandoned clay pits and brick kilns attracted adverse attention. The City of Perth began filling the pits and fencing the site but by 1894 a grander vision to develop the site into public gardens had evolved. Under the direction of Sydney Landscaper Mr. A. W. Farris who was engaged by the City of Perth for the purposes and the City's head gardener, John Braithwaite, the pits were transformed into ponds. Rustic timber bridges and limestone grottoes were built and the ground turfed and planted with trees. The place was renamed firstly as East Perth Park and then at the official opening in October 1899, as Queen's Gardens in honour of Queen Victoria.

*Walking Directions:*

City East extension: continue west along Hay Street to site 53: Roads paved with ... jarrah?

### 55. Sewage Pumping Station No 1

In November 1869, William Dale, Inspector of Nuisances, reported that there had been much sickness, including fever, in Perth in recent years, attributable to bad drainage and problems with disposal of sewage.

In February 1914, Perth No. 2, Hill Street (later known as Langley Park) was commissioned and completed and Perth No. 3, Causeway, was commissioned and completed in June that year, although both bear signs indicating completion a year earlier in 1913. Thenceforward, through to the 1970s, pump attendants, known as 'pumpies' covered a circuit, per bicycle, from Claisebrook to Subiaco each day to check each of the stations.

There was little change to the design or function of the three Perth stations over more than 60 years.

In 1989, a new central sewage station was built in Perth, to the rear of the Mounts Bay Road bus station, and the three low level sewerage pumping stations at Perth (1913 and 1914) were decommissioned.

## PERTH'S ENGINEERING HERITAGE – WALKING TOUR GUIDE

### *Walking Directions:*

City East extension: Make your way east to the Causeway Bridges, cross both bridges to site 67 : Causeway Bridges, located at the Engineering Heritage Marker interpretation panel on the south side of the abutment.

### **56. Perth Trams - 1899 to 1958**

Perth tramways were initially operated by a British company, Perth Electric Tramways Limited. Track construction started on January 30, 1899, and services officially started on September 28 of that year. The first line ran 4.8 kilometres along Hay Street, from the car barn in East Perth [near the WACA cricket ground] to Thomas Street, West Perth.

Further lines were built in subsequent years to Subiaco, Nedlands, Mount Lawley, Victoria Park, North Perth Osborne Park and Inglewood.

In 1913 the State Government purchased the system and embarked on a program of track and fleet renewal, with some expansion. New tramcar bodies were constructed at the WAGR workshops at Midland Junction.

The depression followed by the war had thrown together a combination of factors which eventually proved to be lethal for the tramways: an aging tramcar fleet, aging infrastructure and years of delayed maintenance had all compounded by heavy use during the war years.

The fact that much of the track was single, including some at the side of the road, would have meant additional expense if it were decided to modernise the tramway system. Also increased use of private cars, especially after the ending of petrol rationing in 1949, reduced tram patronage and increased crowding on the roads.

Tram lines were progressively closed from 1950 and replaced by trolley busses, with the main lines closing in 1958. The last tram No. 66 ran from the Inglewood terminus to Barrack St on 19 July 1958.

There is a postscript on No. 66. After completing its run, it was ceremoniously escorted into the East Perth car barn by a band of marching girls. Fifty three years later in 2011 the restored #66 was recommissioned on the Tourist tramway system at Whiteman Park and was escorted out of the car barn by the same group of marching girls.

### *Walking Directions:*

City West walk: From here you can see site 33: The Bell Tower

### **57. Site of 1839 canal**

From the earliest days of settlement, navigation of the Swan River had been inhibited by 'the flats', an area of shallow water and muddy banks in the area where the causeway bridges are now located. Only flat-bottomed boats were able to reach the deeper waters upstream and cargo had to be manhandled from one side of the flats to the other.

In 1831 Reveley developed designs for a channel to be cut through the neck of the Burswood Peninsula, turning Burswood into an island. The canal was to be 275 yards (250 metres) long, 12 feet (3.6 metres) wide and up to 8 feet (2.4 metres) deep.

By 1833 a committee was convened to identify further improvements to navigation through the flats. The committee's report implied the banks of the original canal had become unstable, recommending redigging the canal to full depth with improved construction techniques, including the use of wattled fencing, treading down of mud placed behind the fencing and plantings of rushes on the banks. The canal was also proposed to be extended an additional 78 chains (1.5km) to reach Perth Water.

These canals turned out to be only partially successful and at a meeting of the Road Trust in 1839, Surveyor General John Septimus Roe was given the dual tasks of erecting a bridge and causeway across the flats, and also digging a new canal around the western bank of the river, near the current boundary of the WACA Cricket Ground. The canal was some 500 yards (450 metres) long and ten feet (3 metres) wide, with the contract let to John Crane for £250.

[see also site 66: Burswood Canal]



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### 58. Gloucester Park Automatic Totalisator

In 1916, the WA Trotting Association installed Australia's first (and the world's second) automatic totalisator machine at the WACA ground. The purely mechanical automatic odds machine was the earliest on-line, real-time, data processing and computation system in the world.

While working for the WA Government Railways in 1909, engineer George Julius invented a mechanical device to count votes, but on receiving little interest from electoral officials, he adapted the technology to calculate horse racing odds.

The first Julius totalisator was constructed in Julius' workshop in Sydney for installation at Ellerslie, New Zealand. The WA Trotting Association installed two machines, the first at the WACA and the second here at Gloucester Park in 1929, following WA Trotting Association's move to its new home.

The 1916 Julius Tote was purely mechanical and was known as a "28 horse six clerk machine." It was capable of selling up to 500 tickets per minute, more than three times faster than the quickest clerks under the previous hand-selling system. Prior to the Julius totalisator, punters had to visit different selling windows to place bets on each horse. The new automatic tote allowed punters to purchase tickets for any horse in the race from a single clerk, who was equipped with a machine that could sell tickets on 28 different horses. Each machine was connected through a series of cables and gears through a mechanical adding machine to the registration board outside of the building, showing in real-time the number of tickets sold on each horse.

The 1929 system, in use inside the building shown in the image, was electromechanical with thirty eight terminals. Unfortunately the machinery is long gone, but you can still see the building and the display wall which showed the live odds for each horse as bets were placed.

Interestingly, Julius married the daughter of that other eminent engineer, C Y O'Connor.

*Walking Directions:*

City East extension: Head south along Hale St to site 56: Former Perth Trams carbarn

### 59. Claisebrook Cove Septic Tanks and Bacterial Beds

Following the introduction of clean and reliable water supplies into the City the problem remained of what to do with the waste that the ever growing city was creating. Up until about 1880, disposal of household sewage was an individual responsibility, with private cess pits (580 in 1878). These were cleaned out when required by eight registered night soil carters and the night soil used as fertilizer on market gardens.

In 1880 the Perth City Council instituted a pan collection system utilizing private contractors, and in 1894 took over the total running of the system in 1894. By 1897 the scheme had grown to 42 men collecting from 6270 closets once a week. Fremantle and Midland had similar schemes.

By the late 1890's disposal of this amount of night soil was becoming a serious problem, so a number of studies were put in hand to look at a fully reticulated sewerage system. Various schemes were trailed until work started in 1906 to fully reticulate Perth with the sewers discharging into a large septic tank at Claisebrook. The effluent from this tank was then transferred via a siphon arrangement across the river to filter beds at Burswood.

This 7ML septic tank is still in existence and remains in use as an overflow storage tank for the Claisebrook Sewerage Pumping Station. It can be seen alongside the entrance to the pump station as part of the retaining wall for the parkland above (which is actually on the roof of the tank).

Almost as soon as it was commissioned in 1912 there were complaints of smells emanating from the Burswood Sewerage Treatment Plant. Despite this, demand from the rapidly growing city was such that the works were steadily expanded to ten filter beds by the 1920's. The smell increased accordingly with the hot dry summer of 1922 not only exacerbating this problem but also nutrients leaching from the filter beds causing massive algae blooms which extended as far as Freshwater Bay.

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The only solution was to treat the sewerage elsewhere and disposal of the effluent out to sea. A new Sewerage Treatment Plant and ocean outfall was constructed at West Subiaco in 1924 but it wasn't until 1936 with the completion of a sufficient length of the Perth Main Sewer that Burswood was finally able to be taken off line.

*Walking Directions:*

City East extension: Continue south along Trafalgar and Waterloo St to site 58: Gloucester Park Automatic Totalisator

### 60. Site of the Perth Gasworks

The East Perth Gasworks operated here from 1924 to 1971. The plant used a distillation method to convert coal to town gas, a fuel used for lighting, cooking and heating. At a cost of £105,000, the plant replaced Perth's first gas plant in Wellington Street, which was by the 1920s struggling to keep up with demand from Perth's growing population. The new plant had 16 gas distillation retorts and a spiral guided gas holder with a capacity of 750,000 cubic feet. An 18-inch cast iron main connected the new plant with the old gas works and piped distribution system and cost £105,000.

The new plant was efficiently laid out, such that the coal dropped directly into the coal store from railway trucks on the elevated railway siding. A two-ton electric self-tipping truck then passed the coal into the hoppers of the coal breaker. The crushed coal then travelled by elevator to the bunkers in the top of the retort building, from where it was charged through chutes into one of 16 distillation retorts. The coal was heated in the absence of air to release the gas.

After the carbonisation process was completed the coke dropped from the bottom of the retorts into the coke conveyor for removal. The high efficiency Woodall-Duckham vertical retort system produced 15,000 to 18,000 cubic feet of gas per ton of coal - 50% more efficient than the retorts at the old gas plant - and had a total capacity of one million cubic feet per day. The design and construction of the plant was made by the Electricity and Gas Department under the supervision of the gas engineer. Mr. J. Andrew.

The 20-sided gas holder contained a moveable lid able to shift up and down with the volume of gas stored. The telescopic sides of the tank can retract downwards to meet demand and act as a buffer to meet peak demand. By maintaining the gas at pressure, it provides pressure for flow through the pipes to customers, as well as back-pressure to the generating plant.

This was a site of importance for environmental engineering, to ensure clean-up of the contaminated site and redevelopment into the Claisebrook Cove precinct. The remediation included dredging of sediments in the Swan River and capping of contaminants on the land.

To prevent contaminants from re-entering the river, a steel sheet pile wall was installed around the point, while a plastic cut-off curtain was installed along the foreshore zone.

### 61. Railway Bridges

The current Goongoonup Bridge is the third railway bridge to cross at this site. The first was the Swan Bridge, built in 1892 by Atkins and Law. This construction was troubled by difficulties sinking the Jarrah piles into the soft riverbed: they were intended to be sunk 42 feet (13 m) below the water level, but reached this depth under their own weight as soon as they were put in position. Ultimately, they had to be driven to 85 to 96 feet (26 to 29 m) before a solid footing was found.

By 1930, safety concerns led to a second 'temporary' Bunbury Bridge being constructed. Known to locals as 'Big Bunna', this structure was in use for 63 years until a new concrete bridge - the current Goongoonup Bridge, was completed in 1995.

### 62. East Perth Power Station

The East Perth Power Station was constructed between 1913 and 1916 by the WA government at a total cost of £538,000. It was the first State government operated public electricity utility in Australia, and largest power generating facility in the State until South Fremantle Power Station began operation in 1951. It operated for 65 years until decommissioning in 1981.

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Originally a coal-fired (for a short time oil fired) power station, it is one of the few remaining pre world war one thermal power stations retaining its plant and equipment. The plant contains several generations of generators, spanning almost forty years, and one of the most comprehensive in situ collection of steam turbine generating units in the country.

The power station originally operated on 40 Hz. To accommodate later power supply requirements a frequency converter set unique in Australia and a rarity in a world context converted the original power station equipment output to 50 Hz.

The power station was important in the development of the State's coal industry, based at Collie. Coal to fuel the power station was railed from Collie

Coal ash from the boilers was railed across the adjacent WAGR railway bridge and dumped on the site now occupied by the Optus Stadium. The ash trains were originally powered by an electric tramway and one of the electric locomotives is preserved at the Bassendean Railway Museum.

The station was decommissioned and closed in December 1981, as more advanced and cheaper methods of electricity generation made the facility redundant.

### *Walking Directions:*

City East extension: Head south along the foreshore to site 61: Railway Bridges.

Optional detour: You may like to visit the railway heritage display at site 68: East Perth Railway Station. Follow the foreshore north to the road and turn left into Summers

### **63. Matagarup Bridge**

"Matagarup" is the Nyungar name for the whole area - waters included - around Heirisson Island, and means "place where the river is only leg deep, allowing it to be crossed".

The structure is designed as a 3-span steel cable-stayed bridge, with the two piers in the river bed. The bridge maximum height of 72 metres is reached in midspan of the central span. The length between the abutments is 400 metres, with a 160-metre-long central span. The total length of the pedestrian crossing is 560 metres, which includes a 100-

metre ramp at the East Perth end to route pedestrians away from nearby residential areas.

During construction, these steel components, measuring 120m long x 35m wide, were carefully transferred from the site in Burswood onto barges on the Swan River before being lifted by a mega jack for assembly.

Each part of the main arch, weighing 400t, was winched into place.

### *Walking Directions:*

City East extension: Cross the footbridge to reach site 64: Perth Stadium. Optionally, visit sites 65: Burswood Peninsula and 66: Burswood Canal on the way.

### **64. Perth Stadium**

The Perth Stadium is a six-level steel and concrete structure with a colosseum seating bowl of 60,000 seats, designed with the potential to increase to 70,000 seats within the existing structure. A lightweight fabric roof covers 85% of seats and creates a suspended 'halo' effect.

The stadium was the 2018 winner of the Australian Construction Achievement Award, the peak annual award in the Australian construction industry. The construction engineering team developed innovative solutions to overcome very difficult ground conditions that included dealing with a previous land fill site close to alluvial sediment. Site investigations found that the upper eight metres of ground consisted of fill including concrete, fly ash, car bodies and household appliances.

Innovation continued throughout the above ground structure especially the design of the roof trusses, which allowed for a much safer construction as well as a significant saving to the project budget. The roof design was inspired by the swing arm of Marc Marquez's 2012 Moto2 World Championship-winning motorcycle. By turning the arm upside down, the roof's design took shape. The efficient use of steel provided an opportunity to remove much of the material mass from the roof structure.

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### *Walking Directions:*

City East extension: Continue north along the foreshore in front of the stadium. Take the pedestrian subway under the railway, then turn left. Cross the bridge to reach site 62: East Perth Power Station.

### **65. Burswood Peninsula**

The Burswood peninsula took its name from the family estate of English settler Henry Camfield, who arrived in Western Australia on 12 October 1829. Camfield was disappointed with his original land grants in the colony but succeeded in getting Surveyor General J. S. Roe to grant him 1,000 acres which included the peninsula, previously reserved for Crown purposes. The area was eventually taken up with large land grants and the development of roads and bridges became possible due to the convict labour available after 1850. By the 1880s, there approximately 100 houses in the area. A slowly developing economy saw the subdivision and sale of the larger land grants for residential purposes, one of the earliest being the “Victoria Park Estate” in 1887.

The discovery of gold in the 1890s saw a flood of new settlers and by the turn of the century more of the original farms were being converted into residential and commercial areas. This process of urbanisation accelerated in the inter-war period, as well as seeing industrial enterprises such as the Portland Cement Works take up position on the previously unutilised riverside areas. While sewerage treatment plants had been located at Burswood island c.1909, the swampy area was considered a health hazard due to the mosquitos that bred there. The noxious smells and river pollution from the sewerage filtration beds remained a bone of public contention throughout this period. Part of the process of the sewerage treatment during this time was the removal of rubbish from the filtration beds, which was buried in the foreshore of the river. The situation was finally resolved by 1936 when the Metropolitan Sewerage Service was established to replace the aging Burswood plant. The area appears to have still been used as an illegal rubbish dump at this point.

Burswood Tip (also known as the Rivervale Tip for a time) operated from 1946 until 1985. It initially received fly ash from the East Perth Power Station on the other side of the river, but after 1954 also received local rubbish from the surrounding area. It closed for several

years in 1972 but was reopened briefly for general waste in 1978. From 1979 it was only used for the receiving, chipping and storing garden waste and tree prunings before they were taken elsewhere. It was close din 1985 and the land was developed for the Burswood Island Gold Course.

### *Walking Directions:*

To join the Ciy East extension, head north along the foreshore to site 64: Perth Stadium.

### **66. Burswood Canal**

The first of the major alteration to the Swan River to improve navigation was made in 1831 when a canal was cut making Burswood into an island and reducing navigation time up river. Sadly, having no Venetians in the colony, this first attempt proved relatively unsuccessful and a second canal was cut in 1834.

### **67. Causeway Bridges**

In the early Swan River colony, the only convenient way for transport of goods and people between the townships of Perth and Fremantle was by the river. By land, travellers from Fremantle had to follow the south bank to the location where Canning Bridge now stands.

They then had to use a slow and expensive ferry crossing, and then travel overland to a location near the eastern end of the present Causeway bridges. To reach solid ground at East Perth they had to traverse a series of mud flats.

By 1840 a canal had been dug through the flats to allow boats to travel upstream, and by 1843 two wooden bridges and earth embankments were constructed over the canal and mud flats by convicts under the direction of the Royal Engineers. A second Causeway timber bridge crossing was completed in 1867, after the first bridge crossing was almost destroyed by major river flooding in 1862.

The current Causeway bridges were designed and constructed by the Main Roads Department of WA between 1947 and 1952. They were the first bridges in WA to use the composite steel and concrete construction method, which was later adopted for many

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other bridges within the State. A local refinement used a form of prestressing. This involved jacking up the support girders before placing the concrete roadway and removing the jacks after the concrete had cured. This transferred compression into the concrete of the deck, thus controlling shrinkage cracking under heavy traffic.

The successful completion of the bridges was a significant technical achievement and a fitting tribute to long-serving Main Roads Bridge Engineer, E.W.C (Ernie) Godfrey, who had been in charge of the department's bridge section since 1928. The bridges were permanently listed on the Heritage Council of WA Register of Heritage Places in 1998. In 2012 they were awarded an Engineering Heritage Marker by Engineers Australia.

### *Walking Directions:*

City East extension: Return across the Causeway bridges then travel north along the side of the river to site 63: Matagarup Bridge. Alternatively, remain on the east side of the river to take an optional detour to site 65: Burswood Peninsula and 66: Burs

## 68. East Perth Railway Station and Museum

East Perth railway station is located on the Midland line and is adjacent to the East Perth Terminal and the Public Transport Centre. The East Perth Terminal is the Western terminus of the iconic Indian-Pacific, Australia's transcontinental train that connects Perth, Adelaide and Sydney. The Public Transport Centre is the headquarters of the Public Transport Authority which is responsible for all public rail, bus, ferry and coach services; and the State's rail corridors and infrastructure.

The ground floor of the Public Transport Centre houses a small museum area and displays various rail memorabilia. Included in the museum is a historic coach with the following text on the information board:

"This historic railway carriage is one of a pair of carriages imported in 1876 for use on WA's first rail line - the Northern Railway from Geraldton to Northampton which was opened in July 1879. The carriage was manufactured in Birmingham, UK and purchased by the Government for £380.

"Originally known as Northern Railway No.1, the carriage was renamed WAG A1 258 in 1900 when WA Government Railways was established and all lines were linked to Perth.

"The carriage was sold to C. Y. O'Connor at the turn of the century for his private railway that ran between Mundaring and Mundaring Weir to carry staff during the construction of the dam.

"The coach was returned to WAGR in 1909 before being sold to the Carnarvon Works Department in 1912. It was used for the next 50 years on a tramway connecting Carnarvon with Babbage Island until the tramway was closed. The carriage was then sold as scrap and used as a storage shed, until it was obtained by the Gascoyne Historical Society.

"Ownership of the carriage was transferred to Westrail in 1989 and it was carefully restored to its former glory by the Westrail Midland Workshops.

"The restoration of this important historic carriage was funded by Transperth as part of the Perth Urban Rail Electrification Project."

Just to the right of the main entrance to the Public Transport Centre are a commemorative plaque for the inaugural journey of the Indian-Pacific from Sydney on 22 February 1970 and the Engineering Heritage Recognition Program marker and interpretation panel for the Western Australian Standard Gauge Railway.

Outside, on the North side of the Public Transport Centre, is the S-class freight locomotive named 'Bakewell'. The S-class were designed and built at the WAGR workshops at Midland Junction. More information on this locomotive is available from the link below. More locomotives and carriages are managed by Rail Heritage WA at their Railway Museum in Bassendean.